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VIRUS X RESISTANCE IN POTATO[1]

W. J. Hooker[2], C. E. Peterson[3], and Roland G. Timian[4]

Virus X is one of the most important viruses of potato because of its widespread distribution in seed stocks and because of its depressing influence on yield. Resistance to virus X is of considerable interest because of the different types of response within the potato ranging from complete tolerance through hypersensitivity to immunity.

The depressing influence of virus X on potato yields is well esablished in the United States, Europe, and Australia.

In Maine, yield reductions of approximately 12 to 22 per cent were obtained by Schultz and Bonde (46) over a four-year period with virus X-infected stocks of Chippewa and Katahdin as compared with X-free stocks of the same varieties. Lombard (33), in Maine, obtained small but rather consistent increases in yield with X-free stocks of Chippewa, Sebago, and Teton as compared with X-infected stocks. Yield reduction with Chippewa and Katahdin was 6 per cent with virus X in New York (59) and reduced stands were observed in X-infected Sebago stocks. Stocks of Placid infected with masked virus X (41) tended to yield less than those free from virus X.

Smith and Markham (53) have estimated yield losses caused by virus X in the British Isles at 12 per cent. The extent of yield reduction (12) in Majestic and Arran Banner ranged from 5 to 22 per cent depending upon the severity of the X strain present. Clinch and McKay (19) obtained variable yield response to mild strains of virus X in two different clones of Up-to-Date. Lunden (34) observed approximately 11 per cent yield reduction in the variety, Aspotet, over a 3-year period in Norway, and Klinowski (29) reported marked yield reduction in the German varieties Voran and Ackersegen.

Gains in yield of 14 to 27 per cent have been obtained using X-free as compared with virus X-infected stocks of Up-to-Date in Australia (7).

Strain Variation

Variation between isolates of virus X was first recognized by Johnson (28) who isolated strains inciting either mottle or ring spot symptoms in tobacco. Salaman (45) differentiated 6 strains of virus X on the basis of symptom expression in certain varieties of potato as: X^H, masked; X^G, mild; X^L, medium; X^S, severe; X^N, interveinal necrosis; and X^D, foliar necrosis or the virus D of Bawden (10). Except for X^D,

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severity of symptom expression of these isolates in *Datura stramonium* and tobacco roughly paralleled severity on potato. Much the same general grouping was summarized by Clinch (17) except that X^B was used to designate Up-to-Date streak (18) or virus B from Duke of York (21). All virus X strains listed with the exception of X^B produced top necrosis in Arran Crest and Epicure whereas X^B was not top necrotic in these varieties but was top necrotic in Arran Victory and President. Bawden and Sheffield (13) summarized the evidence establishing virus B as a strain of virus X.

Larson and his associates (31) investigated variation within the ring spot isolates of virus X and described symptoms on various hosts and on a number of potato varieties. They suggested that no two cultures of virus X are identical.

Although virus X is generally latent in tolerant potato varieties producing either no symptoms or a very mild mottle, severe forms have been identified in President as foliar necrosis (10), in Majestic as interveinal necrosis (45), in British Queen as a crinkle which produced symptoms of foliar necrosis and leaf drop followed by severe mosaic (17), and in the Up-to-Date variety grown in Australia (6).

In the United States, strains of virus X producing severe symptoms have been obtained from field infected plants exhibiting foliar mottle and necrosis of Chippewa (32) and in seed fields of Sebago, Katahdin, Pontiac, and Red Warba (30). In the latter, lethal top necrosis often developed. Severe ring spot isolates have also been obtained from symptomless plants of certain older American varieties such as Triumph, Green Mountain, Russet Rural, White Rural, Irish Cobbler and Russet Burbank (31).

Within naturally infected potato plants mixtures of X strains are common. Bald and White (9) postulated that within varieties an equilibrium exists between the mild and severe forms. Ladeburg, Larson, and Walker (30, and 31) separated ring spot strains of virus X from the latent mild mottle form of the virus in symptomless plants of the older American potato varieties.

In company with virus X, virus B (Up-to-Date streak) is nearly always present in the variety Up-to-Date (52). A virus similar to that of Up-to-Date streak, probably virus B, was demonstrated (38) in healthy as well as in diseased plants throughout the American material examined. Dykstra (23) found virus B in stocks of Earliest of All, Bliss Triumph, and Burbank and he later reported (24) that Green Mountain was normally a symptomless carrier of both virus B and virus X. Bald and Pugsley (8) reported that virus B was of rather common occurrence in Australia. Mai (35) obtained virus X from Katahdin, Sebago, and Chippewa plants expressing in the field mild mottle to brilliant mottle with necrotic spots but he obtained no evidence that virus B was also present.

The report (4) of an isolate of virus X from an American source which was non-necrotic to the established British varieties field immune from both viruses X and B is of considerable importance because of the potential threat to varieties with this type of resistance.

The mottle inducing strains of virus X (3) spread through potato stocks more rapidly than those inducing necrotic symptoms. There was no indication that these differential rates of spread were caused by

differences in host resistance to the various strains employed but were rather due to the reaction of the host after infection had become established. The necrotic reaction apparently retarded the rate and limited the extent of virus penetration.

Resistance

Within the potato, three rather well defined types of resistance have been identified as; 1, tolerant types or carriers of virus X with symptoms ranging from complete masking to a strong mottle which may be accompanied by necrosis depending upon the strains of virus X present and environmental conditions; 2, field immune or hypersensitive types responding to graft inoculation by well developed top necrosis; and 3, immune types in which the virus fails to survive.

TOLERANT TYPES

The majority of the American potato varieties released to date are tolerant to virus X. Virtually all stocks of the common varieties such as Irish Cobbler, Triumph, Green Mountain, Russet Rural and Russet Burbank are uniformly infected with virus X. Smith (52) listed a number of British and American varieties tolerant to both viruses X and B, a few of which are Arran Banner, Duke or York, Earliest of All, Great Scot, Majestic, and Up-to-Date. A number of varieties top necrotic to viruses X and B in combination were also listed.

Within the group of tolerant varieties, differences in degree of resistance to infection are known. Smith (52) pointed out that the varieties British Queen and Up-to-Date were of approximately the same age yet it was still comparatively easy to find plants of the latter free of virus X. Gladstone and Arran Pilot (3) were more resistant to infection with virus X than Majestic, Arran Banner and Craigs Alliance, and Arran Victory and Kerr's Pink were the least resistant of the group tested.

Considerable information has been obtained by Schultz and his associates investigating the resistance of Katahdin to virus X. Katahdin could be infected with virus X by the leaf mutilation method (48) and it occasionally became infected with X in the field (49). Katahdin plants exhibiting mosaic symptoms in the field were found by Mai (35) infected with virus X. Virus X-infected Katahdin plants (31) were not often seen in the field, but when plants were infected the reaction was severe with severe foliar necrosis or lethal top necrosis. Such plants were sometimes killed before tuber formation.

The rate of virus X-infection in X-free stocks of Katahdin as determined by Schultz *et al* (48) was compared with that of an unnamed seedling of Green Mountain. Individual plants were grown between Triumph plants carrying virus X. Following this exposure, virus X was demonstrated in 70 per cent of the plants of the Green Mountain seedling whereas none of the Katahdin plants were infected. In a similar test, Katahdin plants were not infected when interplanted with virus X-infected Green Mountain whereas 33 per cent of the plants of the Green Mountain seedling were infected under similar conditions. Brushing the tops of the plants with virus X-infected vines of the Green Mountain variety failed to infect Katahdin but infected 58 per cent of the Green Mountain seedling plants. Since top necrosis developed in Katahdin

following graft inoculation it is possible that the B strain of virus X may have also been present.

Earlaine was more easily infected with X than Katahdin (49). In field exposure tests, 62 per cent of the 136 clonal lines developed from a cross, S. 41956 x Earlaine, were X-susceptible and of the X-susceptible clones 81 per cent of the plants were infected. In a comparable test of 127 clonal lines from a cross, S. 41956 x Katahdin, 34 per cent of the clones were X-susceptible and of this group 61 per cent of the plants were X-infected.

Seedlings from a number of crosses in which Katahdin was a common grandparent were used by Hutton (25) to separate strains of virus X. Certain seedlings, when inoculated with a virus X complex, gave necrotic reactions in which the virus was not localized. A small percentage of the necrotic reactors acted as strain separators so that masked, mild, severe, and necrotic strains of the X virus could be obtained.

Bercks (14) referred to the gradual reduction in susceptibility of potatoes to X infection during the growing season as mature plant resistance. He investigated certain varietal and nutritional factors involved.

HYPERSENSITIVE OR FIELD IMMUNE TYPES

The top necrotic reaction, often referred to as field immunity, is considered by Cockerham (20) to be a highly efficient form of protection against a particular virus. In this type, resistance is associated with extreme susceptibility or hypersensitivity to the virus. Top necrosis, or acronecrosis, as described by Quanjer (39) is a necrotic spotting of the young leaves, petioles, and stem tips which kills the tip of the shoot (Fig. 1A). Necrosis of the foliage, stem and tubers is usually initiated in the inner phloem and later extends into the surrounding parenchyma which in turn is surrounded by cork cambium. Bawden (11) described the top necrotic reaction with particular emphasis upon the virus strains involved. This reaction is manifest either as; 1, localized, necrotic lesions on inoculated leaves in which case the virus may not become systemic within the plant; or as 2, systemic top necrosis following grafting with X-infected scions. Eyes of necrotic tubers from top necrotic plants either fail to sprout or produce systemically infected plants which usually do not survive whereas non-necrotic tubers produce plants free from necrosis. Only occasionally are diseased plants observed in the field. Because of this hypersensitive reaction, virus X is self eliminating in certain varieties.

Cadman (15) showed that hypersensitivity to virus X is determined by a single dominant gene, *Nx*, inherited in a manner typical of an autotetraploid. Cockerham (20) reported the occurrence of dominant genes, *Nb* and *Nc* respectively, which condition field immunity to viruses B (the B strain of virus X) and C (a strain of virus Y). Cockerham (21) reported the reaction of 146 named potato varieties to viruses A, B, C and X. Certain varieties top necrotic to virus X but non-necrotic to virus B (genes *Nx and nb*) are Epicure, Arran Crest, King Edward, Edgecote Purple, Ninetyfold, and Southesk. Varieties top necrotic to viruses X and B (genes *Nx* and *Nb*) are Craigs Defiance, Crusader, and Harbinger. Craigs Snow White (1), and Pentland Ace (4) also belong in this group. The *Nx* and *Na* genes (22) are closely linked and cross over values (2) for these two genes have been determined.

FIGURE 1.—A, Top necrosis in Epicure grafted with X-infected *Datura stramonium*. B, Aerial tubers formed on an X-carrying scion grafted to an X-immune stock. C, An X-infected scion grafted to an X-susceptible stock. D, Inoculated seedling plants many of which exhibit systemic symptoms of X infection. Photographs by R. E. Wicklund.

Varieties non-necrotic to virus X and top necrotic to virus B (21) (genes *nx* and *Nb*) are President, Arran Victory, Arran Cairn, British Queen, Jubel, Katahdin, and Kerr's Pink. Mai (35) has determined the reaction of 10 varieties to virus X and B. On the basis of his data Katahdin, Sebago, Sequoia, Pontiac, Seneca, Menominee, Norkota and Erie belong in this group.

Schultz, Clark, Stevenson, and Raleigh (50) determined inheritance of the top necrotic reaction of Katahdin by comparing progenies of S. 41956 (immune) x Katahdin (top necrotic to virus B) to progenies of S.41956 x S. 45075 (susceptible). In the former, 23 per cent of the seedlings were top necrotic as compared with none in the latter. In each cross, 37 per cent of the plants were virus X immune.

Varieties non-necrotic to X and B but often showing a mottle (recessive genes *nx* and *nb*) (21) are Duke of York, Shamrock, Up-to-Date, Majestic, and Irish Chieftan. It also appears (35) that Ontario, Cayuga, and Empire belong in this group.

In most of the varieties studied by Cadman (15), the *Nx* gene is carried as a simplex, *Nx nx nx nx*, but in the variety Cardinal it is carried as a duplex, *Nx Nx nx nx*. Resistance was similar when the *Nx* gene was present in either the duplex or the simplex condition.

Three virus X isolates of German origin have been demonstrated (4) to produce top necrosis in potato varieties carrying either or both genes *Nx* and *Nb*.

Ross and Kohler (44) compared a number of virus X isolates representing both the X^N and the X^E groups in graft tests to more than 100 potato varieties. Varieties Condor, Heida, Hilla, and Parnassia were non-necrotic to any isolate and Fortuna was hypersensitive to the 7 isolates of the X virus tested. Varietal reactions to the different virus strains were given.

IMMUNE TYPES

Potato seedlings resistant to virus X inoculated by leaf rubbing or by tuber grafts were first described by Schultz and Raleigh (51) who used such seedlings to eliminate the virus X component from other viruses present in certain mosaic disease complexes. Although no specific progeny was named in this report, it seems probable as suggested in a later paper (47) that S. 41956 was one of the seedlings described. S. 41956 has been repeatedly tested for resistance to virus X and in no instance has it become infected with the virus (4, 17, and 55), or with the related forms of virus X, virus B (8, 13, 16 and 21), or virus D (24).

Raleigh (40) demonstrated the immunity of S. 41956 by grafting scions containing latent virus X to stocks of S. 41956. Aerial tubers were formed on virus X-carrying scions grafted to immune stocks (Figure 1B). When aerial tubers were well developed, underground portions of the stocks failed to develop and necrosis was often severe. When susceptible stocks were used with virus X-infected scions, no aerial tubers formed (Figure 1C). No aerial tubers developed when X-free scions were grafted to resistant stocks.

Virus X was apparently readily transmitted downward (17) through an intermediate scion of S. 41956 double grafted to a susceptible variety.

Intermediate scions of S. 41956 served as barriers to upward movement of the virus permitting passage of virus X in only a few instances whereas no such barrier was effected in similar plants by an intermediate scion of an X-susceptible variety. Virus X could not be recovered from the intermediate scions of S. 41956 (17) nor from tubers (16) of grafted plants. Other attempts (4) to recover virus X from tubers of S. 41956 to which virus X carrying scions had been grafted were also unsuccessful.

It is problematical whether the resistance of S. 41956 to virus X should be considered immunity in which the virus fails to become established within the plant or whether the resistance is due to extreme hypersensitivity. Raleigh (40) observed that S. 41956 when grafted to a plant carrying the latent mosaic virus "developed a very slight necrotic spotting of the leaves which in some instances was barely noticeable." The same response of S. 41956 grafted with virus X carrying scions has been noted (4) and it was suggested that the resistance may be that of extreme hypersensitivity. Hutton (26) suggested that the immune reaction and the localized reaction or hypersensitivity were phases of the same biochemical reaction. Up to 80 per cent of the seedlings carrying the X-immune factor gave necrotic reaction when inoculated with virus X under conditions of relatively low temperature.

Hutton and Wark (27) reported the isolation of virus X from inoculated leaves of an immune seedling, 11-48, similar in type to S. 41956, as well as from inoculated leaves of localized reactors, Epicure and 47-20, and from inoculated leaves of a susceptible variety, Up-to-Date (Factor). Virus X was recovered in a very low percentage of isolations from inoculated leaves of 11-48 within the first 3 weeks following inoculation. The virus was recovered consistently but in low frequency from inoculated leaves of Epicure and 47-20 over the 28-day period of isolation suggesting reduced virus concentration in these leaves. With the exception of the first few days, virus X was recovered consistently and in considerable concentration from inoculated leaves of Up-to-Date.

S. 41956 was a selection from a cross made by C. F. Clark (45) involving S. 24642 as pollen parent crossed with a seedling selection from Villareola selfed x (American Wonder x Sutton's Flourball). S. 24642 (also one of the parents of Katahdin) had been highly resistant to virus A in field exposure tests (47) and S. 41956 was only slightly less resistant to virus A with an average of 7 per cent infection in 1925, 1927 and 1930 whereas Green Mountain averaged 43 per cent infection.

Hutton and Wark (27) suggested that the recessive allelomorph of a gene in the nulliplex condition resulted in immunity, whereas the dominant gene in the quadruplex condition gave complete susceptibility. The simplex and duplex conditions conceivably could have given phenotypes with localized reactions.

Stevenson, Schultz, and Clark (56) adequately investigated the inheritance of immunity in S.41956 and they postulated tetrasomic inheritance characteristic of autotetraploids. Immunity is based upon the presence of both a dominant gene *A* and a dominant gene *B*. S. 41956 apparently is of the genotype *AAaa Bbbb* whereas the susceptible genotype is *aaaa bbbb*.

NATURAL OCCURRENCE OF VIRUS X RESISTANCE IN *SOLANUM* SPP.

Within uncultivated species of potatoes resistance to virus X is known in a few instances. Cockerham (20) reported the gene, *Nx*, in 26 clones of five species, *S. tuberosum, S. andigenum, S. Parodii, S. curtibolum,* and *S. Fuzepezukii.* The gene, *Nb,* was identified in 13 clones of *S. andigenum* and *S. curtibolum.*

Certain collections of *Solanum acaule,* Blossfeld, La Pena blanca, and Bukasov, contained individuals apparently immune to virus X in ioculation tests by Stelzner (54). Later (4) the immune reaction was identified in two clones of *Solanum acaule,* numbers 379.1 and 2106.1, of the Commonwealth Potato Collection. The parents of the former were homozygous and the latter heterozygous for immunity. The presence of the gene, *Nx*, in certain accessions of the Commonwealth Potato Collection was demonstrated. Ross and Baerecke (42) tested 18 collections from 12 *Solanum* spp. and identified immunity from virus X in two collections of *S. acaule,* Bitter and Rosensteil-Bitter. In 27 crosses involving a large number of *Solanum* spp. no immunity to virus X was identified. Ross and Baerecke (43) identified immunity in all plants from a cross *S. acaule* Bukasov x *S. acaule* Rosensteil.

Virus X immune *S. acaule* P.I. 175395 and P.I. 175396 are listed (5) in the 1953 seed and tuber list of the Inter-Regional Potato Introduction Station, Sturgeon Bay, Wisconsin.

VIRUS X RESISTANCE IN A BREEDING PROGRAM

In a breeding program the advantages attendant with the use of different sources or types of resistance should be considered provided a choice is possible. The chief advantage of the type of resistance associated with field immunity or hypersensitivity is that the virus is self-eliminating in the field. This type of resistance has been favored by Cockerham (22), Bawden and Sheffield (13), and Lunden (34), although the identification of an isolate of virus X (4) of American origin non-necrotic to varieties field immune to virus X is of some concern.

For a test of field immuity, at least two plants of each clone are required, one plant to maintain the progeny and a second for the actual test .Therefore the test can not be made until the seedling has been increased for one growing season.

At the Iowa Agricultural Experiment Station an effort was made to develop a means of selecting from a seedling population of potatoes the segregates immune from virus X. Resistance of S. 41956 was incorporated in the parentage of seedling populations tó be tested. The principal advantage of a screening program initiated at the seedling stage was the early elimination of susceptible segregates before transplanting.

For the initial work a severe ring spot isolate of virus X *(XRS),* obtained from R. H. Larson (31) was used. This isolate served particularly well because in most instances on susceptible X-free potatoes it incited necrosis on inoculated leaves followed by systemic mottle and necrosis.

A comparison was made by Timian (57 and 58) between the graft test of Raleigh (40) (Figure 1, B and C) and mechanical inoculation in 169 clones of potatoes. The clones exhibiting necrotic spotting of inoculated leaves at 16° C. were apparently susceptible, whereas those

exhibiting no necrosis were immune. Clones classified for resistance using the mechanical inoculation method were of similar resistance when Raleigh's graft test was used.

Two seedling populations segregating for immunity to virus X (57 and 58) were inoculated with the XRS isolate. Approximately 250 plants in 3-inch pots were tested. Individuals with local necrosis of inoculated leaves were considered susceptible (Figure 2) whereas those showing no necrosis were considered immune. Non-necrotic plants were used for inoculating *Gomphrena globosa L.* and none were found to be symptomless carriers. Local reactors often became systemic, but in some, virus X was apparently confined to local lesions on inoculated leaves. This type of resistance was not studied further.

Symptoms on seedling plants inoculated in the second true leaf stage (Fig. 1D and Fig. 3A and B) consisted of necrotic local lesions on inoculated leaves or stems and a necrotic flecking or strong mottle when the virus became systemic. No reaction was observed on immune plants.

Eight isolates of virus X were compared on four seedling populations of potatoes two of which were completely susceptible to virus X and two of which were segregating for immunity to virus X. Virus X isolates were purified by using a local lesion host, *Nicotiana rustica* L., after the method of Ladeburg, Larson, and Walker (31). Plants were inoculated when the second true leaf was 4 to 6 mm. wide by rubbing the first and second leaves with a virus-carborundum mixture. One isolate, X5, was particularly effective in inciting local necrosis of inoculated leaves in 3 to 5 days at 16° C. and in the development of systemic symptoms in 6 to 15 days. All of the susceptible plants were infected locally and systemically with X5. Strain XRS was equally effective in producing necrosis in inoculated leaves but it did not produce systemic symptoms in all susceptible plants. A very mild isolate, X8, symptomless on *Datura stramonium* L. produced symptoms on only 40 per cent of the susceptible plants. Other isolates ranged between X8 and X5 in effectiveness. These isolates ranked relatively the same when compared on a number of susceptible potato clones propagated from tubers.

Symptoms on inoculated leaves of seedlings developed equally well at 18 and 24° C. with both XRS and X5. At 10° C. symptom expression was slightly retarded with X5 and decidedly reduced with XRS. Systemic development was markedly reduced with X5 at 10° C. as compared with 18 and 24° C.

Breeding for Immunity to Virus X

The selection of plants immune to virus X by screening seedlings in flats before transplanting to the greenhouse bench has important advantages over the graft test which must be performed after field selections have been made. In the potato breeding program of the Iowa Agricultural Experiment Station seedling plants were sprayed with a mixture of virus X inoculum from *Nicotiana glutinosa* L. and 400 mesh carborundum using a paint spray gun, 15 pounds pressure, with a plant to nozzle distance of 1 centimeter. Plants were inoculated at the second true leaf stage and non-necrotic plants were transplanted to 3-inch pots in the greenhouse bench.

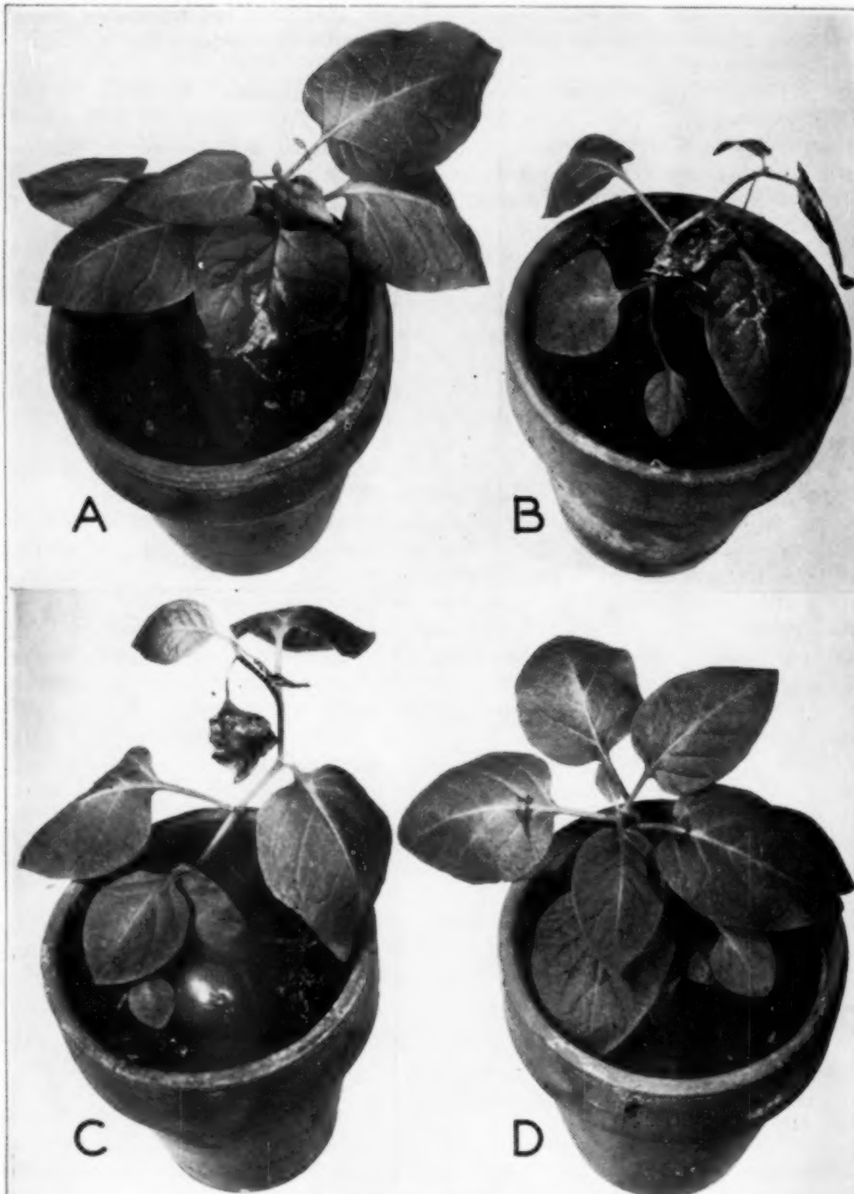

FIGURE 2.—Symptoms of virus X-infection on seedling plants 22 days after inoculating the leaves marked with India ink.
A, Necrotic spotting of inoculated leaf and very early systemic necrosis in upper right leaf.
B and C, Inoculated leaves severely necrotic and systemic top necrosis of the plant.
D, No symptoms, either local or systemic on an apparently immune plant.

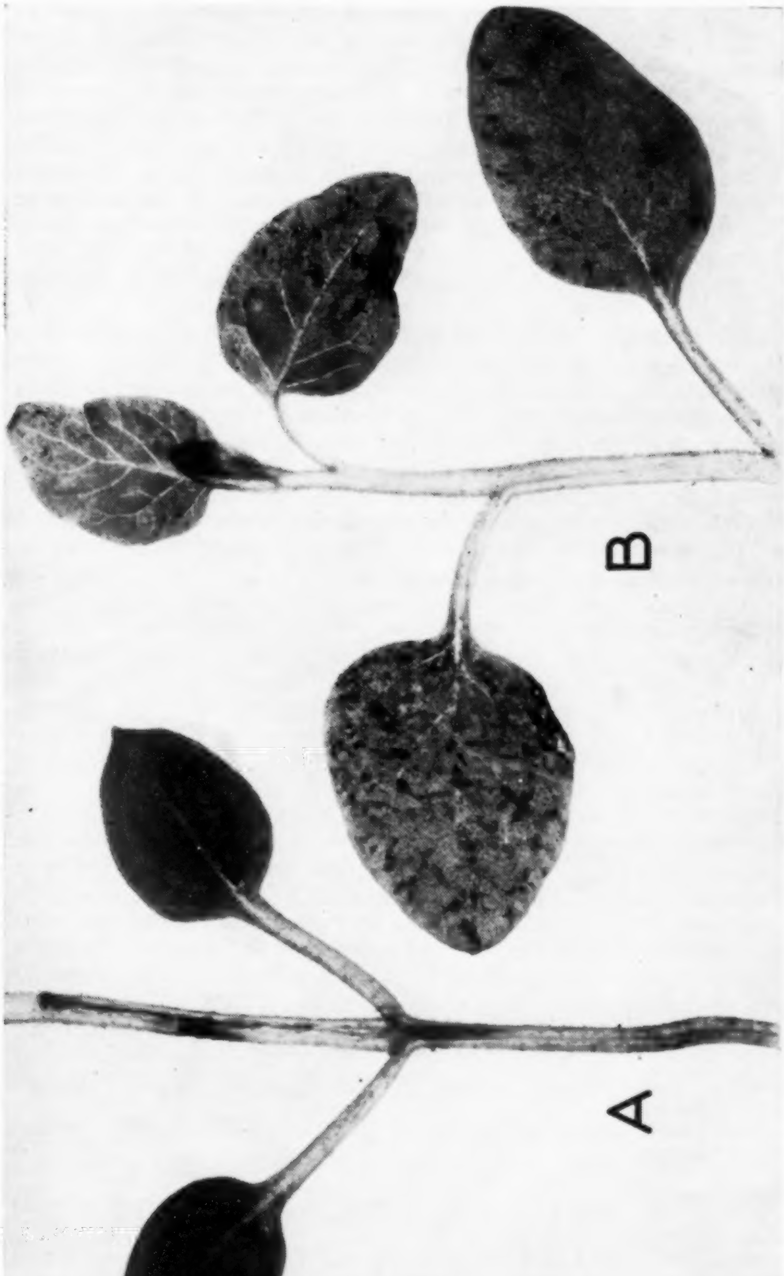

FIGURE 3.—Symptoms of virus X infection on seedling plants 14 days after spraying with a mixture of inoculum and carborundum. (A) Lesions on cotyledons and stem; and, (B), on leaves.

A few flats of seedlings were screened experimentally in 1949 to determine if the method could be adapted for large populations of segregating seedlings prior to transplanting. The following year seven progenies were screened and approximately 900 surviving plants were grown to maturity producing tubers for field planting. In 1951, fourteen progenies were screened in seedling flats and more than 1500 surviving plants produced tubers in the greenhouse. Subsequent tests on some of these progenies revealed that more than 98 per cent of the plants grown in the field were immune to virus X. In later trials, where seedling populations were not as rigidly examined for local and systemic symptoms of virus X, the serological test described by Munro (37) was used to identify X-carrying susceptible plants.

By 1952 screening procedures had been stabilized so that it was possible to screen 43 progenies and to transplant to the greenhouse more than 10,000 seedling plants that survived the first screening in flats. Reinoculation after transplanting and late symptom development resulted in the elimination of another 10 to 15 per cent of the transplants. After some selection of the seedling tubers approximately 7,000 remained for production of first-year hills in the field in 1953. Also in 1953, 35 X-immune selections were included in observation plots.

Most progenies tested have resulted from crosses of an immune parent by a susceptible one and, although there has been some variability between progenies, most have segregated approximately 50 per cent immune plants.

Three X-immune selections from this program were included in yield trials at Clear Lake, Iowa, in 1952. One of these, Ia. 803-3, was outstanding among the 22 varieties and selections in the trial. It matured as early as Cobbler and produced a higher yield of U. S. No. 1 tubers than did Cobbler. The cooking quality of Ia. 803-3 was also equal to Cobbler and its tubers were smooth and free from grade defects. It is also resistant to common scab and to four (A, B, C, BC) of the races of the late blight fungus (36) against which it has been tested. The performance of Ia. 803-3 must be tested over a series of years before it can be accurately judged. Results thus far with this and other selections demonstrate that virus X immunity can be rather easily combined with important horticultural qualities and resistance to other diseases. Progress in this direction has been hastened by an efficient means for screening large seedling populations.

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A STRAIN OF POTATO-VIRUS Y INDUCING LOCAL AND SYSTEMIC NECROTIC SPOTS ON LEAVES OF TOBACCO WHITE BURLEY[1]

K. SILBERSCHMIDT, E. ROSTOM AND C. MATTOS ULSON[2]

On tobacco the normal strains of potato-virus Y are known to produce veinclearing followed by very slight mottle. The occurrence of the spot necrosis reaction is considered (2) as a strong evidence for the presence of both virus X and virus Y in the inoculum.

Other strains of potato virus Y have been described (1, 3, 4, 8) which produce systemic symptoms of a necrotic type on leaves of certain tobacco varieties. The strain under study at the Biological Institute seems to belong to this group.

During an excursion to Paranapiacaba (Serra do Mar) the senior author collected crinkled leaves of a non-flowering solanaceous plant (*Solanum* sp.). Healthy plants of *Nicotiana Tabacum*, L., var. White Burley and of *Nicotiana glutinosa* L. were inoculated with sap obtained from those leaves. The symptoms produced on *N. glutinosa* consisted of crinkling and malformation of the leaves and in stunting, whereas the new leaves of infected tobacco plants exhibited a large number of yellow necrotic flecks and afterwards veinbanding (Figure 1). In successive transfers to new series of healthy tobacco plants this symptom was always observed. A limited number of small necrotic spots was also observed on young plants of *N. Tabacum* var. *Havana*, inoculated mechanically with the same virus. On plants of *Datura stramonium* var. *tatula*, no symptoms could be induced. The thermal inactivation point was found to lie between 55° and 60° C. In preparing saps from leaf areas, consisting only of flecks, a large number of yellow spots were produced on the new leaves of inoculated plants, which were always followed by the veinbanding symptom.

The virus was readily transmitted to White Burley tobacco by the peach aphid *Myzus persicae* (Sulz), which is additional proof that this symptom cannot be attributed to an X-virus component. In the transmission experiments the yellow flecks appearing on the young leaves were specially clearcut (Figure 2). Several series of experiments were performed to study the influence of the length of the acquisition feeding period (7) on transmission. The results of experiments with batches of 10 apterae of *Myzus persicae* which were fed for variable time periods on infected tobacco leaves and then transferred for an unlimited test feeding period to healthy tobacco plants, are summarized in table 1. In all these experiments the aphids passed through a fasting-period of 3 hours prior to acquisition feeding.

Each figure of the table represents the percentage of infected tobacco plants of a total of 16 inoculated plants, tested in 4 replications, each of which consisted of 4 plants.

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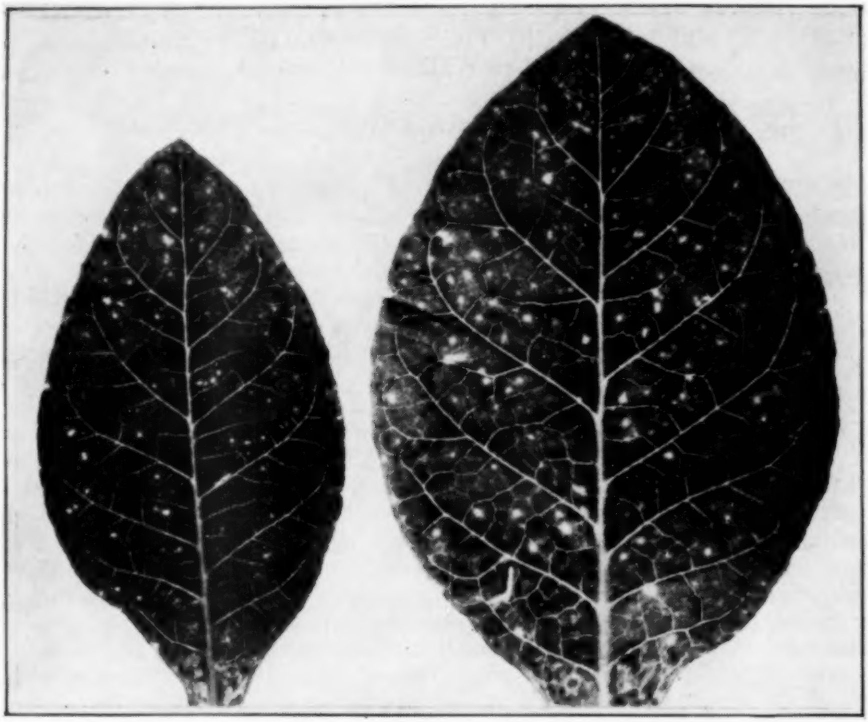

FIGURE 1.—Medium (left) and older (right) leaves of *Nicotiana Tabacum* var. White Burley, infected mechanically on August 13, 1952. (Photograph taken September 13, 1952.)

TABLE 1.—*Percentage of transmission of the necrotic strain of potato virus Y to plants of Nicotiana Tabacum var. White Burley after varying periods of acquisition feeding.*

	Acquisition Feeding Period in Minutes					
	60	30	15	10	5	2
Per cent Infected Plants	50.0	43.7	81.0	75.0	100	93.7

The tests show that the percentage of transmission was higher after relatively short acquisition feeding periods of 2 or 5 minutes, than after longer periods of 60 or 30 minutes.

These observations agree with the results obtained by Watson and Roberts (9) for non-necrotic strains of potato-virus Y. These authors found a higher percentage of infection by potato-virus Y after an acquisition feeding period of 2 minutes than after one of 15 minutes.

It seems worth mentioning that some years ago A. Orlando and K. Silberschmidt, studying transmission of a necrotic strain of potato

FIGURE 2.—Leaf of *Nicotiana Tabacum* infected on March 16, 1953 by *Myzus persicae*, (Photograph taken April 10, 1953)

virus Y by the same insect, found an acquisition feeding period of 30 minutes slightly more favorable than one of 2-5 minutes. Darby, Larson and Walker (2) in their experiments on strains of potato-virus Y fed the aphids during 10 minutes on the infected plants, that is somewhat longer than would be in accord with our optimum acquisition feeding period.

In most of our experiments the length of the test feeding period was not limited. More recently we performed a few experiments transferring batches of viruliferous aphids to successive series of healthy tobacco plants, using test feeding periods of 5 and in other experiments 15 minutes. In one of these experiments, in which we chose a test feeding period of 15 minutes, all of the 4 successively tested tobacco plants became infected. In other tests the transmission was intermittent. In all cases the tobacco plants, to which the aphids were transferred immediately after the acquisition feeding, became infected much earlier than those of the successive transfers. In one of our experiments, the "prepatent period"

for the 4 tobacco plants of a series, in which the transfer of the same viruliferous aphids from plant to plant was performed after a test feeding period of 15 minutes for each plant, was found to be 12, 17, 20 and 22 days, respectively.

Comparing the new strain of potato virus Y, dealt with in this paper, with the necrotic strains of the same virus formerly described, we find that the necrotic round lesions which it induces in White Burley tobacco are very similar to those observed by Smith and Dennis (8) in White Burley tobacco and by Costa, and Forster (1) in Sumatra and turkish tobacco.

The strain described by Nobrega and Silberschmidt (4) in 1944, harbored by a potato tuber originating from Peru is slightly different in the symptoms induced in White Burley tobacco, since they consist primarily in necrosis along the smaller veinlets. Round necrotic spots may occur only in a very late stage of disease induced by that strain of potato virus Y. Finally, we consider it interesting to point out that South America seems to be a center of the natural range of those strains of potato-virus Y, which produce necrotic lesions on tobacco. The source plants of all those strains so far described were found in South America, with the possible exception of the strain described by Smith and Dennis (8). In this latter case, the existence of an eventual relation between the occurrence of this disease and the presence in the neighborhood of potato plants grown from tubers obtained from South America, cannot be excluded.

In this connection it may also be mentioned that recently Pushkarnath (6) in India, described a virus disease of *Solanum jasminoides,* attributed to a strain of potato virus Y, which was probably introduced from South America.

Summary

Expressed juice of a spontaneously infected plant of *Solanum* sp. induced small round, yellow chlorotic spots on the inoculated and the younger leaves of plants of *Nicotiana Tabacum* var. White Burley. They are frequently accompanied by stunting of the plant and by veinbanding of the young leaves. No symptoms could be induced in *Datura stramonium,* whereas *Nicotiana glutinosa* presented only veinbanding and crinkling of the leaves. The thermal inactivation point was found to lie between 55° and 60° C. The round, yellow spots on leaves of White Burley could be induced not only by sap inoculation, but also by viruliferous aphids of the species *Myzus persicae,* (Sulz.). By using batches of 10 apterae of *Myzus persicae* for each test plant and by choosing an acquisition feeding period of 5 minutes following a starvation period of 3 hours, the yellow, round spots could be induced in 100 per cent of the tobacco plants inoculated. We consider the causal virus under study a strain of potato-virus Y, possibly related to the necrotic strains.

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STORAGE BEHAVIOR OF FIELD-SPROUTED POTATOES[1]

J. M. Lutz,[2] and Herbert Findlen[3]

"Field sprouting", or "heat sprouting" of potatoes in the field frequently occurs in the warmer portions of the southern states (2) and has also been reported elsewhere (1, 3, 4, 5). Generally field sprouting is associated with unusual drought or high temperatures or both. A rather large amount of field sprouting of the Pontiac and Red Pontiac varieties was observed in the Red River Valley of Minnesota and North Dakota during the 1951 growing season. By August 1 sprouts, up to 4 inches long (Figure 1), were observed on tubers 1 to 2 inches in diameter. These potatoes had been planted in May in relatively dry soil. May was very dry, with only 0.16 inch of rain (2.34 inches below normal). The temperatures averaged 58.6°F. (4.4° above normal). Our rainfall in June was about normal, but July was very dry until July 29, when 1.2 inches of rain fell. Irish Cobbler and Triumph, both earlier maturing varieties than Pontiac, did not show any evidence of field sprouting. This observation agrees with the results reported by LeClerg and Henderson (2), who found that heat sprouts were more prevalent in late-maturing varieties than in earlier ones. On August 13, nearly 100 per cent of the tubers in several hills, selected at random in a field of Red Pontiac potatoes, revealed sprouts. This was an unusual case, as some fields did not have nearly so many sprouted tubers.

At harvest time (about October 1), very little field sprouting was noted. Most of the sprouts observed previously had apparently dried up and fallen off. Instances were observed where sprouting had been followed by tuber formation and the "daughter" was larger than the "mother" tuber. Other evidences of second growth such as "dumbbell" shapes were observed. Because of the extensive field sprouting there was considerable concern regarding the keeping quality of these potatoes. In order to obtain information on this point, approximately 100 apparently normal Red Pontiac tubers and a like number of tubers showing field sprouts, were selected on October 22, 1951, from a field that had shown a very high percentage of field sprouting at an earlier date. The sprouts had started to dry when the potatoes were harvested and during the storage period many fell off. All tubers were then placed in a commercial storage in which the temperature was gradually lowered from 48°F. to 40° during a 2-week period, was maintained at 36° to 40° until April 15, and then gradually increased to 58° by May 15, 1952. The relative humidity in the storage was 85 per cent.

On November 15, 1951, 25 tubers from the field-sprouted lot and an equal number from the normal lot were placed in a warm room maintained at 55° to 58°F. and 45 per cent relative humidity. On February 8 a second group of 25 potatoes from each lot was placed in this warm

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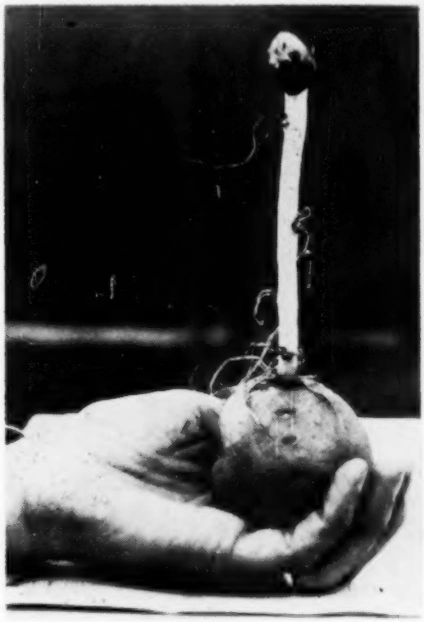

FIGURE 1.—Field-sprouted Red Pontiac tuber with small tuber formed at the end of the sprout.

room. The potatoes remaining in storage were inspected for sprouting on May 15, after being subjected to rather high storage temperatures during the last month of the storage period.

Discussion of Results

It can be noted in table 1 that in the lot of potatoes that was transferred from storage to a warm room on November 15 (when fall-crop potatoes are normally considered to be still in their rest period), the tubers that showed field sprouting developed new sprouts earlier and in greater abundance than did the normal tubers (Figure 2). This indicates that the rest period of these field-sprouted tubers was terminated sooner than that of normal tubers. The earlier breaking of the rest period was evident in a commercial bin of Pontiac potatoes harvested after October 1 and observed on November 9. Some sprouts were approximately 4 to 6 inches long on November 9, indicating that the rest period had been broken at least a week previously or a month earlier than normal. Air temperature in the storage was 48°F. Sprouts so early in the season are not normally seen, even at fairly high storage temperatures. Other instances of earlier breaking of the rest period in individual tubers showing evidence of field sprouting were observed.

TABLE 1.—*Sprout development in normal and field sprouted Red Pontiac potato tubers.*

Length of Holding Period in Warm Room (Weeks)	Type of Tuber	Removed from Storage to Warm Room on:					
		Nov. 15, 1951		Feb. 8, 1952		May 15, 1952	
		Length of New Sprouts (Inches)	Weight of New Sprouts per Tuber (Grams)	Length of New Sprouts (Inches)	Weight of New Sprouts per Tuber (Grams)	Length of New Sprouts (Inches)	Weight of New Sprouts per Tuber (Grams)
0	Normal	—	—	—	—	0.2 to 2.0 mostly 0.5 to 1.0	3.0
	Field-sprouted	—	—	—	—	do	1.0
2	Normal	0	—	0.2 to 0.5	—	—	—
	Field-sprouted	0 to 0.1	—	do	—	—	—
3	Normal	0	—	0.2 to 1.0	—	—	—
	Field-sprouted	0 to 0.2	—	do	—	—	—
4	Normal	0 to 0.5	—	0.5 to 2.0	—	—	—
	Field-sprouted	0.5 to 1.0	—	do	—	—	—
6	Normal	—	0.5	1.0 to 5.0	12.7	—	—
	Field-sprouted	—	1.0	do	6.7	—	—

In the lot of tubers transferred from storage to the warm room on February 8, 1952 (when potatoes are normally considered to be out of their rest period) and in the lot of tubers left in storage until May 15, the lengths of sprouts on the 2 types of tubers were approximately the same. However, the weight of sprouts on the normal tubers was greater. During the shipping season it was noted that after the rest period was normally terminated field-sprouted tubers developed less vigorous sprouts.

This weaker sprout growth of field-sprouted tubers seems to agree with the observations of Muenster and Boulenoz (4), who reported that plantings of this type of tuber were inferior to the control and recommended that neither stoloniferous tubers nor twins be used for seed.

These results and observations indicate that potatoes that have been field-sprouted can be stored successfully, but it is especially important that they be cooled to 40°F. rather quickly after curing and that the curing period be held to a minimum.

FIGURE 2.—New sprouts on Red Pontiac potatoes transferred from storage Nov. 15, 1951 and held 6 weeks in warm room. Left: normal tubers; right: tubers showing evidence of field sprouting when harvested.

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POTATO NEWS AND REVIEWS

MARKETING ORDERS AND THE POTATO INDUSTRY[1]

JOHN I. KROSS[2]

The potato industry and the federal government have been perplexed with re-occurring surplus problems for the past 35 years. Various reasons have been given for the surplus problems; (1) the extreme yearly fluctuations in potato production, (2) the relative inelastic demand for potatoes, surpluses resulting in price depressing situations, (3) the declining *per capita* consumption of potatoes, (4) and the recent changes in production practices. There is an additional reason for having surplus crops, resulting from the price-support programs. Farmers have produced eight bumper crops of potatoes in eight consecutive years. In no previous eight-year period has the average production been so high as in the 1943-1950 period. Even with the removal of price support programs potato surpluses will continue to reoccur in the future. Consequently, every effort should be made to adopt marketing programs which will bring about better adjustments in the so-called supply-consumption relationships. These programs should aim toward stabilizing prices and result in bringing satisfactory returns to producers.

Several approaches have been made by the government in handling surpluses through purchase programs, even before price supports became mandatory through federal legislation. But the handling of surplus crops cannot be done entirely by the federal government. The responsibility to market surplus crops and to effectuate production adjustment should mostly fall upon the shoulders of the potato industry.

MARKETING AGREEMENTS

One type of program which has been advocated and promoted to obtain industry participation in handling surpluses is made available through the Agricultural Marketing Act of 1937 as amended. This Act provides for a variety of regulatory activities. Through this regulation it is possible to regulate the flow, control qualities and quantities of potatoes marketed in commercial channels, provide for surplus controls, reserve pools, price posting and elimination of unfair trade practices.

The President of the United States in his message to Congress recommended a more liberalized approach to marketing agreements and orders. Senator Aiken on March 2, 1954 introduced a bill, S-3052, a portion of the bill would amend the Agricultural Marketing Act of 1937 to include some of the President's recommendations. Basically the most important provisions which could affect potato growers' income are already contained in the Agricultural Marketing Act of 1937 as amended.

Several people believe that marketing orders are the tools for the potato industry to use in doing away with low prices, disorderly marketing

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conditions, extreme price fluctuations and surpluses. However, experience for a 12-year period with marketing orders did not indicate that marketing orders can solve potato marketing problems. As a matter of fact, in 1950 seven marketing order programs were rejected, although price supports were an added inducement.*

Development of Order no. 60

The experience obtained from the operation of Potato Order No. 60 should provide valuable information in appraising the usefulness of this instrument in handling potato marketing problems in the Midwest.

Order No. 60 became effective January 26, 1942 based upon findings obtained from public hearings conducted in Cadillac, Michigan; Grand Forks, North Dakota; Antigo, Wisconsin and St. Paul, Minnesota. However, the Order was not active during the war period and remained dormant until the crop of 1946. Because of the large crop in 1946, potato representatives from the four-state area met to consider reactivating the Order. Records indicate that the Red River Valley representation pressed for termination of Order No. 60 and was in favor of developing a new Agreement and Order solely for the Valley area (North Dakota and Minnesota). However, due largely to the efforts of representatives from Michigan and Wisconsin this move was blocked. The Wisconsin and Michigan representatives argued that it was more economical and otherwise more advantageous for them to operate under Order No. 60.

Meetings were held in the spring of 1947 in each of the four states to nominate new committee members for the four-state Central Administrative Committee, presently operating with headquarters at St. Paul, Minnesota. The principal points involved in reactivating the Order were:

(1) Order No. 60 became a legal instrument in 1942 but regulations were not issued until 1947. Economic problems facing the potato industry had changed materially from 1942 to 1947. The potato acreage in Wisconsin, for instance, dropped from 150 thousand acres in 1942 to 96 thousand acres in 1947. Likewise the number of farmers growing potatoes in Wisconsin declined sharply and the average size of potato acreage per farm was larger than it was in 1942.

(2) The decision to reactivate the Order was determined by members of the original Administrative Committee, a few growers in each state and members of the federal government. Some growers have questioned whether this group had sufficient authority to act for the industry in this situatioin. However, the Order was already on the books and available to function at any time the Administrative Committee requested the Secretary of Agriculture to issue regulations controlling marketing operations.

Who Determined the Original Four-State Grouping?

There has been some question, for instance, why the four-state arrangement, and not three states or even five states, should constitute a logical group. It is apparent that the four-state grouping was based upon

*Price Supports and the Potato Industry, University of Minnesota, Agricultural Experiment Station, Bulletin No. 424 and North Central Regional Publication No. 43, page 9.

an administrative decision and did not result from an economic analysis.

It has been argued by some producers that Wisconsin is situated in an unsatisfactory grouping because production and marketing conditions are dissimilar from states associated in the Order.

Issues Involved at Antigo, August 14, 1951

The purpose of the hearing was to obtain evidence with reference to (a) general economic conditions in order to effectuate the declared policy of the Marketing Act of 1937, and (b) specific provisions which a marketing agreement and order should contain.

The public hearing records were examined to ascertain to what extent information provided by witnesses substantiated the purposes stated above. The following general statements can be made concerning (a), lengthy and descriptive material was presented on various aspects of the potato industry. However, it is apparent that witnesses at the Antigo hearing did not present adequate information concerning farm and market prices, relations of prices to parity, available market, supply from Wisconsin and competing areas, grower returns and other pertinent economic factors which are vital in determining the need for operating a marketing order instrument in Wisconsin. Most likely analysis relative to those economic issues was made by governmental marketing specialists based on other than information presented at the Antigo hearing. A thorough presentation covering point (b) was made by representatives of the U.S.D.A. in explaining the mechanics of the marketing order in lengthy detail, such as establishing committees, operations of committees, compliance, termination, expenses and assessments, reports, *etc.*

The testimony offered by federal representatives covering shipments led growers to believe that the regulations resulting from the Order will pertain only to potatoes sold in *interstate* commerce. The following are excerpts taken from the hearing record.[2] "Free to be sold and moved within the state and where produced — provisions do not effect the movement or sale of potatoes within the state of production."

Potato growers in Wisconsin voted on the agreement and order believing that regulations would not affect *intrastate* shipping and selling. The letters[3] sent to potato producers accompanying the ballot used in the referendum contained the following "prohibits shipment between states of potatoes below U. S. No. 2 grade or less than 1½ inches in diameter," with no reference to intrastate shipments. The presumption is that they would not be affected. Order No. 60 therefore, did affect the handling of potatoes in intrastate commerce.[4] This condition has brought about considerable misunderstanding and a reluctance on the part of growers and handlers to accept the Order in Wisconsin.

Basis for Issuance of the Order

The Agricultural Marketing Act of 1937 contains powers enabling the Secretary of Agriculture to issue a marketing order when such order

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[2]Page 200, Docket No. A0159, SMA, U.S.D.A.

[3]Letters sent to growers by chairman of the County Agricultural Conservation Committee.

[4]Sec. 960.4, Order No. 60, General Cull Regulation — "no handler shall ship potatoes which do not meet the requirements of U.S. No. 2 or better grade."

is "approved by at least two-thirds of the producers within the production area participating in the referendum." By administrative decision the production area was defined to include North Dakota, Minnesota, Michigan and Wisconsin.

In the original referendum about 5,100 growers voted in favor of the order in the four states. The favorable vote was nearly 80 per cent of the total vote.

In the second referendum (held in 1950 to determine including Iowa and Indiana) a total of 5,568 growers voted in the six states, of this number 4,179 (77 per cent) voted for the order and 1,389 (23 per cent) voted against the order. Those favoring the order by volume were likewise more than two-thirds of the production, which was also the result in the first referendum.

The United States Department of Agriculture ordered a third referendum to be held from July 9 to 13, 1951, to determine whether or not Order No. 60 should be continued. There was a considerable amount of disagreement among the administrative committee as to whether or not Order No. 60 should be continued. This dissolvment was favored by nine members of the committee and eight members voted continuation of the order. The third referendum found that 62.6 per cent of the growers participating in the referendum favored termination of the order and they represented approximately 14 per cent of the commercial potato growers in the production area. The Secretary of Agriculture, on August 15, 1951, terminated the order because of the lack of support for the amended order shown in the referendum. The Secretary concluded that the Order no longer effectuated the purposes of the Agricultural Marketing Act, as amended. The United States Department of Agriculture in terminating the order had taken the opposite position when the order was enacted. Although in the initial referendum less than 10 per cent of the potato growers in the production area participated in the referendum, the United States Department of Agriculture approved making the order operative.

It is worthy to note that in all three referendums not more than 15 per cent of the commercial producers affected by the order participated in the voting. There has been an inconsistency about the United States Department of Agriculture's ruling with reference to enactment and termination of potato marketing orders. The enactment was based on two-thirds of the growers voting approving the order and termination was based on the majority of growers producing 50 per cent of the volume for market. The Secretary of Agriculture can also terminate the order without a growers' referendum.

The Congressional Hearing Record[5] on H.R. 5585 to amend Agricultural Adjustment Act brought out conclusive evidence that: (1) Marketing orders had to be confined to small areas with no conflicting producer interest present. (2) Marketing orders were to be approved when "two-thirds of the farmers or producers affected wanted such an agreement to be put into effect." It appears that the intention of Congress when it included marketing orders into federal legislation was to confine the order to the smallest feasible area and enactment was to be based

[5]Statements made by Honorable Chester C. Davis, Honorable Henry A. Wallace and Mr. Boileau, Hearing Record serial has been, February 26, 27, 28, March 1, 5 and 6, 1935 on H.R. 5585, 74th. Congress, 1st. Session.

on approval of two-thirds of the growers in the area. However, the United States Department of Agriculture on Order No. 60 considered the outcome of the referendums on the basis of two-thirds of the growers voting.

Regulations Issued Under Order No. 60

Although the Order was reactivated during the 1946 season no regulation existed for that crop year.

1947-1948 Season

The first regulation was a cull regulation,[6] section 960.4 of the Order No. 60, which was approved and became effective on September 22, 1947.

Exemption for potatoes having hollow heart was requested by the Red River Valley area, and on October 5, 1947, this became effective in certain counties; and continued throughout the 1947-48 shipping season.

Exemptions from the cull regulation were granted Wisconsin producers, on account of field frost, by the Secretary of Agriculture for a period of twenty days commencing October 24 and ending November 15. Later this exemption was extended by the Secretary for the balance of the year ending July 1, 1948. Federal-state inspection was required on all potatoes prior to shipment.

1948-1949 Season

The hollow heart exemption was again granted to North Dakota and Minnesota effective November 5 extending through the remainder of the 1948-1949 shipping season.

The North Central Potato Committee on October 18 submitted a request to the Secretary of Agriculture to approve a grade and size regulation which would prohibit the shipment of any potatoes failing to meet requirements of U. S. commercial grade and of size B potatoes. The grade and size regulation became effective November 8 and extended through the remainder of the shipping season. Federal-state inspection was required on all potatoes prior to shipments.

1949-1950 Season

A hollow heart exemption was granted Wisconsin producers from November 10 to November 27. The Secretary of Agriculture, upon request of the North Central Committee, issued a regulation effective November 28 prohibiting shipment of potatoes failing to meet the requirements of U. S. commercial grade and 1⅞ inches minimum size.

Effect of the Regulation on Market Supply

It is doubtful if the above regulations seriously curtailed the available market supply of potatoes from commercial areas. The cull regulation did not reduce total supply because shippers do not handle these unmerchantable stocks anyway. Furthermore, issuing a grade and size regulation after harvesting operations were completed could not have materially changed the available market supply from the four-state area. After the November 28 period when the grade and size regulation were put into effect, the crop had already been harvested and it is reasonable to assume that a majority of the stocks in warehouses would grade U. S.

[6]Potatoes which do not meet the requirements of U. S. No. 2 or better grade, as such grades are defined in said "U. S. Standards for Potatoes."

commercial 1⅞ inches in diameter or better. However, issuing U. S. commercial grade and size regulations commencing with August 1 of each crop year would have reduced the total supply in the four-state area.

It is questionable if curtailing supplies of even U. S. commercial quality in the midwest area would have resulted in higher incomes to potato farmers. There are considerations in addition to quality which enter into potato surplus situations such as seasonal production, concentration of volume production, transportation, and displacements in the major markets. When considering sales policy you must take into account the relationships of potato prices to supplies. Dr. O. C. Stine made the statement that "Probably there will not be agreement among analysts as to the exact relationship of potato prices to supplies. We find that the demand for potatoes is inelastic. An analysis indicates that beginning with 350 million bushels, the addition of 1 million bushels to supply reduces the price about .8 cents a bushel. Given 400 million bushels the increase of 50 million bushels at .8 of a cent per million would tend to reduce the price by approximately 40 cents per bushel." Therefore, it becomes quite evident that effectiveness of regional or state orders as a price enhancing device is highly limited. There is no assurance that effects of action taken by the region or state will not be nullified by other producing states or areas.[7]

Perfect conditions for increasing farm income through marketing orders would exist when you had complete control of supply and complete control of demand. The further you deviate from the perfect conditions the more impossible it becomes to increase farm income for a specific commodity. In ranking potatoes against these perfect conditions, we have to place potatoes at the bottom of the scale.

Potato Quality

The quality of potatoes shipped during the entire 1948-1949 season from the four states varied considerably. It was ascertained that almost 98 per cent of the inspections made in Michigan graded U. S. commercial grade or better, 87 per cent in Wisconsin, 83 per cent in Minnesota and 78 per cent in North Dakota, (See table 1). It might be said that, of the four states, Michigan shipped the best potatoes and North Dakota the poorest. However, this evidence should be qualified by the low compliance in Michigan and Wisconsin.

Compliance

The information presented above on quality is not complete because inspections do not cover all of the shipments made in the respective states. For instance, inspections in North Dakota covered 95 per cent

[7] . . . . . the United States represents a single market for potatoes. Because of extensive interregional movements, direct competition between potatoes from all sections exists in most important consumption areas. No single section supplies enough of the total United States market to increase the incomes of its producers by restricting sales. Maine ,for example, produces only about 10 per cent of the total crop. If Maine acted alone to restrict sales, it would find that the price increases resulting from this action were proportionately less than the quantity restrictions involved, therefore the Maine producers were reduced. Price Supports and the Potato Industry, University of Minnesota Agr. Experiment Station Bulletin No. 424 and North Central Regional Bulletin No. 43, page 27.

TABLE 1.—*Car, truck and warehouse inspections covering shipping season 1948-1949.*

	Minnesota	North Dakota	Wisconsin	Michigan
	Per cent	Per cent	Per cent	Per cent
U. S. No. 1 Size A	31.34	20.48	49.56	74.73
U. S. No. 1	23.52	15.73	9.53	8.42
U. S. No. 1 Size B	1.17	.55	2.11	1.19
U. S. No. 1—1½ & 1¾" min.	.02	.34	.00	.00
U. S. Commercial Size A	22.92	27.02	23.80	1.29
U. S. Commercial	5.01	14.36	3.69	13.06
U. S. Commercial Size B	.13	.06	.07	.00
U. S. Comm.—1½ & 1¾" min.	.26	3.53	.00	.00
U. S. No. 2 Size A	9.74	9.21	3.31	.63
U. S. No. 2	4.81	6.96	6.28	.26
U. S. No. 2 Size B	.00	.02	.00	.03
U. S. No. 2—1½ & 1¾" min.	.00	.29	.00	.00
Unclassified				
Serious Hollow Heart	.50	.54	.00	.00
Rot	.02	.08	.08	.00
Other Defects	.49	.77	1.39	.34
Total All grades and sizes	100.00	100.00	100.00	100.00

Source: North Central Potato Committee Report, June 10, 1949.

of the marketable crop, whereas inspections covered 83 per cent of the marketable crops in Minnesota, 58 per cent in Wisconsin and only 48 per cent in Michigan. (See table 2). Stated in another way, growers in North Dakota and Minnesota did a better job of complying with the order than growers in Michigan and Wisconsin. Perhaps, in Michigan and Wisconsin, only those potatoes grading commercial or better were inspected. In North Dakota, with a concentrated supply area and mostly rail shipments the low quality potatoes are less likely to escape inspection and compliance.

Wisconsin and Michigan have access to primary and secondary markets and considerable volume is moved through truck deliveries directly from

TABLE 2.—*Grower compliance with order No. 60 for 1948-1949 shipping season.*

State	(1) 1948-49 Crop	(2) Crop* Sold	(3) Quantity Inspected	Column 3 as Percentage of Column 2
	Bushels	Cwt.	Cwt.	Per cent
Michigan	16,350,000	7,848,000	3,794,725	48
Wisconsin	10,875,000	5,220,000	3,029,088	58
Minnesota	16,740,000	8,035,200	6,693,418	83
North Dakota	20,295,000	9,741,600	9,296,255	95

*Based on 1945-1947 average U. S. crop disposition data show that 80 per cent of the nation's crop was sold and 20 per cent used for feed, home use and seed purposes.
Source: North Central Potato Committee Reports.

the farms. Largely because of this condition it is difficult to get inspections on all shipments emanating from Michigan and Wisconsin production areas. There is another condition which should be considered with reference to the lack of compliance in Wisconsin which stems from the fact that growers in certain sections of the state have not been acquainted with the order. However, this latter condition is not so important as the conditions previously mentioned.

Free Market System Best

The nature and character of the potato industry seem to lend themselves best to a free market system, with sound credit policies playing the dominant role in balancing supply in line with market requirements. Potato production should be recognized for its speculative interest and elements involved and a "market price variability" program[8] will not eliminate speculation or change the make-up of the individuals who practice it. Price risk will always be present and it is impossible to legislate their elimination from our economic system. An active educational program on the business aspects of production and marketing, and an educational program on factors making and affecting prices will help to minimize growers and handlers from taking costly chances. Under a free market system potato prices fluctuate widely, however, fortunately they are short lived. Under a free market system we have reoccurring low market prices but we also have reoccurring periods of high prices and periods of moderate levels of prices. Under the free market system, all supplies are required to clear through the market enabling (1) price-making forces to have their fullest effect, and (2) allowing supplies to move through the private handler so that he can intelligently conduct his normal business and necessary service in the marketing and distribution system. Experience and research results indicate that farmers in the long run make more money under a free market system.[9]

Because of climatic and seasonal factors, imperfect knowledge of major markets, perishability of potatoes, and concentration of volume production, the potato industry experiences temporary market displacements. Under these circumstances, discretionary governmental purchases to take care of only the immediate situation would be desirable. Government purchases should be designed to move potatoes only into diversion channels — starch and flour factories, limited animal feeding operations and relief programs at home and abroad.

The potato industry becomes greatly concerned and naturally so with surplus problems. However, there are other problems common to growers in all producing sections of the United States which require constant vigilance for their solution. These problems are quality (appearance and culinary) grades and standards, marketing and production efficiency, elimination of cuts and bruises, establishing sound merchandising, advertising and packaging programs. The handling of these

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[8]Price Supports and Potato Industry, University of Minnesota, Agricultural Experiment Station, Bulletin No. 424 and North Central Regional Publication No. 43, pages 28, 29, 30 and 31.

[9]Ibid, pages 25 and 26. Under a free market, prices to producers were higher than under controlled programs of price supports and marketing orders.

problems is within the grasp and domain of producers and handlers on a voluntary basis.

Legislation will not eliminate these problems. However, a realistic educational program and a desire on a part of the industry to tackle them will help to alleviate their seriousness and result in higher returns to producers.

Conclusions

Basically, when appraising potato marketing orders, the main issues center around economic and administrative questions. From an economic standpoint marketing orders have not increased farm income for potato producers, even when allied with potato price support programs. The administrative problems have been complex and difficult to carry out under rapidly changing conditions of production and demand. Marketing orders were made operative on the entire industry in the six states even though not more than 15 per cent of the producers participated in the referendum. Hearing records appear to indicate that the intention of Congress was to have enactment of the order when two-thirds of the growers affected in the area approved the order.

ANNOUNCEMENT OF ANNUAL MEETING

The Annual Meeting of the Potato Association of America will be held in conjunction with the American Phytopathological Society at Estes Park Conference Camp, Estes Park, Colorado, August 24-28, 1954.

1. LODGING ACCOMMODATIONS:

(a) Lodges and Sleeping Cabins — Rooms for 2 or 4 persons each. For families without children or with 2 small children and individuals who can room together. Indicate any preference for a room mate. No cooking facilities.

(b) Cabins for Families — For families with 2 or more children including families of 4 or more if one child is 11 or older. Cooking facilities in some cabins, however regular conference rate required from head of family plus a slight charge for other family members.

2. DINING ROOM ACCOMMODATIONS:

Three dining rooms available so that all guests may eat at one time.

3. SERVICE — Maid service, towels and all bedding furnished. A hostess shall be in charge of the lodges. Experienced hikemasters, naturalists, guides, horsemen, *etc.*, will be available.

4. RESERVATIONS —

(a) Families (man, wife and children) deadline June 30, 1954. Families with 2 or more children should indicate desire for cabin with cooking facilities if required.

(b) All others must make reservations by July 31.

Send all reservations to Dr. R. H. Porter, Botany and Plant Pathology Department, Colorado A & M College, Fort Collins, Colorado.

5. RATES —

(a) Conference Rates (includes lodging and meals). For adults (12 years and over) $25.00 each; for children (7 to 11 yrs.) $21.00 each; (2 to 6 yrs.) $18.00 each.

(b) Daily Rates (includes lodging and meals). For adults (12 yrs. and over) $6.50; children (7 to 11 yrs) $5.50 each; (2 to 6 yrs.) $4.75 each. All persons attending the meetings of the Phytopathological Society and the American Potato Association, and staying at the Camp will be expected to pay according to the conference rates as listed. Members of families who wish may also pay regular conference rates. Members of families who wish to prepare their own meals may do so, but will be charged a reasonable fee for lodging. In addition, they will pay for the Chuck Wagon dinner if they wish to attend.

(c) The Chuck Wagon Dinner, Wednesday night included in Conference rate. An extra charge will be made for persons who do their own cooking. Their desire to attend this dinner should be noted in reservation request. This will replace the usual banquet.

6. TRANSPORTATION — Purchase railroad and bus tickets to Estes Park; Air line tickets to Denver. The Rocky Mountain Transportation bus serves Estes Park and the Conference Camp.